Landscape change and its drivers: A Southern African perspective

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Abstract

Global environmental change is of immense importance as it shows how humans relate with nature. Within global environmental change debate landscape change analysis is a crucial cog as it expresses how humans relate with the land. Comprehending landscape changes, and its drivers are crucial in forging policies that can mitigate against negative effects of global environmental change. Research on the spatial component of mapping landscape change through land use and land cover maps is well documented in the literature. However, understating the drivers of landscape change remains poorly understood particularly from developing countries in Africa. The main drivers of landscape change in Southern Africa, are mainly attributed to local causes and global causes. The challenge is how one can adequately comprehend these drivers so as to develop sound land management practices. A framework that is transdisciplinary and that leverages on big data is proposed for the effective modeling and management of landscapes in Southern Africa.

Introduction

Since time immemorial people have always depended on the landscape to survive. With the growing population, more pressure has been put on the land to provide food through agriculture and housing for the urban population [1]. Importantly, the burgeoning population has put pressure on the need for increased agricultural production and it has brought about negative effects such as pollution and habitat fragmentation. These impacts know no boundaries and they have been severe in developing countries in particular African countries [2].

Landscapes are part of the global environment change, sustainability and climate change debates [3,4]. Comprehending the causes of landscape change as well as the evolution of landscapes is important in global environmental management and mitigating against climate change in Southern Africa. There is therefore a strong need to comprehend landscape change, its drivers and how to model landscape change. Research on the spatial component of mapping landscape change through land use and land cover maps is well documented in the literature [5-8]. However, grasping the

drivers of landscape change remains poorly understood [9-12]. A search on Scopus dated 8 December 2017 has shown that there is an increase of research on land scape change from less than 100 research papers in 1995 to 609 in 2017, which shows the increasing importance of landscape change in the global environment and sustainability debate. However, there is paucity on research on landscape change in Africa and Southern Africa in particular [2,13]. This review endeavors to document what are regarded as the main drivers of landscape change, and proposes how to model and manage landscape change optimally in Southern Africa.

The first part of the paper provides an overview of the drivers of landscape change in Southern Africa. The next section focuses on how best to comprehend and model landscape change so that best practices to manage the landscape are implemented. Lastly the conclusions and future directions are discussed.

Landscape change and its drivers

The landscape is often described as the prime sphere where the interactions of human beings and the environment become evident and where the combined effects of nature as well as society becomes visible [9]. Changes in the environment due to land use can negatively affect the functioning of the ecosystem [2,14]. These changes have been mainly driven by expansion of agricultural activities and human settlements [15]. Understanding the impact of land use change on the environment due to agricultural and urban uses is important to inform government policy. Change is an inevitable constant. The interaction of humans with the environment to derive useful resources has altered the structure of the landscape [16,17]. Changes in landscapes are often a reflection of global, regional, and local trends such as climate change, urbanization and agriculture intensification respectively [18]. There is often a lack of knowledge on the dynamics of land use and landscape evolution and the complex role socio-economic factors play in landscape evolution, particularly at detailed local scales in individual small catchments. This is quite true in African countries, for example, little is documented on the impact of Zimbabwe's fast track land reform program [17]. Moreover, it is the small communities in rural communities and poor communications that are often at the mercy of the negative effects of landscape change in Southern Africa[14].

Recently, landscape change has attracted increasing interest because of its impact and close relation to climate change, sustainable development, and its impact on food security [11,19].There is consequently a pressing need to understand the drivers and causes of landscape change. Driving forces are the forces that cause observed landscape change; processes that influence the evolutionary trajectory of a landscape [10]. The four major driving forces of landscape change, are political, cultural, socio-economic, and natural or spatial driving forces [10,18] (Figure 1).

Policies, legal instruments and institutional arrangements have a huge bearing on landscape change. The policies can either be local or international [16]. For example, the Fast Track land resettlement program in Zimbabwe has led to poor management of natural resources leading to negative impacts such as soil erosion and deforestation [20-24]. Similarly, in South Africa the Spatial Planning and Land Use Management Act (SPLUMA) is a major legislation seeking to regularize optimal management of land

uses [25-27]. Landscape change is also impacted by international statutes and what happens beyond the country's borders, particularly in this era of climate change.

Socio-economic forces include poverty and unemployment that cause people to cut trees for sale in Southern Africa. For example, due to the high unemployment rate in Zimbabwe, people cut down trees to resale as firewood and also plunder natural resources for commercial benefit [28-30] . Similarly, in South Africa the majority of the youth in rural areas migrate to urban areas leaving the elderly to tend the fields. The high rate of urbanization has also seen consumption of pristine agricultural land for urban uses [1,31]. The markets (consumer demands, market structure, and subsidies) often drive changes in the landscape [19,32-36]. For example, agricultural intensification as a result of high consumer demand has given rise to concern over landscape sustainability, which determines the capacity of a landscape to consistently provide long-term landscape ecosystem services [37]. Agriculture has been responsible for reshaping the natural world more than any other human activity. In South Africa, there is a growing need for food as the population has grown at approximately 2 % per annum. As a result of declining profits, agriculture has shifted towards intensive farming, which if poorly managed, often leads to land degradation [38].

Culture certainly leaves an imprint on the landscape. For instance, in Southern Africa homesteads in rural areas are demarcated using cultural norms and over stocking by rural livestock farmers is seen as a sign of wealth which has led to land degradation [39,40]. Similarly, in Southern Africa, people in rural areas still use traditional methods of farming [41]. Nevertheless, people in rural areas have also adopted, technology and modernization in their faming and this has had both a positive and negative impact on the landscape [38]. There is also a strong attachment to land in Southern Africa [42]. Land is an emotional aspect and it is connected to identity, spirituality, and the cosmos [43-45]. This has positive and negative effects on landscape change. For example in rural areas land is communal, it is not private unlike the colonial view of private property [42]. A forest can be referred as spiritual leading to its conservation whereas land invasions on national, parks, state land or private poverty which are common in Southern Africa usually entails negative impacts on the land such as cutting down of trees [21-23,42,46].

Natural or spatial driving forces relate to indicators such as slope, topography, soil characteristics, spatial configuration, and natural disturbances [18]. Many studies have focused on the spatial or natural driving forces on landscape change [3,10,47]. However, despite the external natural drivers, [48] argues that landscape change can happen without any change in external drivers. Rather change can occur as a result of self-organizing change where current changes are caused by internal systems, wherein system components interact with each other. The drivers of landscape change in Southern Africa are useful in modeling and managing landscape change.

Modeling landscape change

Twigging the drivers of landscape change remains largely poor due to the variation of existing case studies over spatio-temporal scales and the spread of landscape studies across various boundaries [18,47]. Modeling and the management of landscape change to ensure national and global sustainability requires a concerted effort between

all parties concerned (Figure 2). Firstly, local policy makers and institutions should take into cognizance the role played by international treaties and statues as these provide an enabling framework in modeling and mitigating against the negative impacts of landscape change [49]. Similarly, the work of academics and scientists together with localized knowledge from community members is an integral part of comprehending landscape change. There is also a need to focus on four challenges facing studies on landscape changes namely (i) studying processes not merely spatial patterns, (ii) extrapolating results in time and space, (iii) linking data of different qualities and (iv), considering culture as an important driver of landscape change [9]. What this entails is a call for an interdisciplinary approach in landscape change studies as opposed to a sectoral approach [12].

The way forward on landscape change studies includes expanding the scope of studies in underreported areas or regions such as Southern Africa, long term studies that go beyond use of satellite imagery, consideration of subtle process of landscape change, landscape change studies across boundaries or transects, landscapes and persistence, rates of change, and standardization of cross studies [10,11,16,18,47,49].

Likewise, the local community and indigenous knowledge's is also an integral in providing information and knowledge of landscape change. With all parties together all their expertise, provide data, information and knowledge on landscape change. Ideally, the data has to be hybrid and big data that combines formats including, remote sensed data, crowdsourced data, local narratives and other data collected from traditional methods of data collection such as surveys [50,51]. This huge amount of big data provides volume, velocity, variety and complexities of data, making it possible to comprehend landscape change, its drivers and impacts holistically [52,53]. It is possible to acquire the big data for landscape analysis because of the increased processing power of computers, the availability of open source and high resolution remote sensing data such as the global urban footprint and global land cover data [54]. Lastly, for greater impact it is advisable that the data be open access. Modeling landscape change analysis also allows for feedback loops to the various players as they provide means of shaping and implementation mechanisms of best landscape management practices (Figure 2).

Sustainable landscape planning and management

Landscapes are not only the most operational scale for understanding and shaping the relationship between human society and environment, but also the most important places for providing landscape services as well as achieving human wellbeing [55]. Landscape sustainability is defined as the capacity of a landscape to consistently provide long term, specific landscape ecosystem services essential for maintaining and improving human wellbeing. Therefore, Landscape sustainability research is of great significance for humans [56]. Landscape sustainability has the characters of interdisciplinary, multi-dimensional, and emphasizes resilience and landscape regeneration [55]. Landscape services is also an important concept in the Landscape sustainability research. It is not only a key bridge between natural capital and human wellbeing, but also the closely linking bonds between landscape sustainability and landscape ecology. The new paradigm "pattern-process-design" produced a major breakthrough in landscape sustainability research [57].

Conclusion

The literature highlights that landscape change is a critical component of the global environmental change debate. Landscape change in Southern Africa and developing countries is a huge challenge given the growing urban population and the need to feed this population by intensifying agricultural production. There is a strong need to study the drivers of landscape change from a local perspective so as to develop effective and sound land management practices. Local drivers of landscape change such as culture, population, policies are intertwined with other drivers at a global scale such as international statutes. In order to model and implement sound land management practices a transdisciplinary approached as opposed to sectoral approach is proposed. This approach acknowledges that all stakeholders have a role to play and it leverages on big-data to effectively model landscape change. Landscapes are also critical for sustaining ecosystem services. The future of landscape studies looks bright given the advancement of data collection methods, processing techniques and the increased of sharing knowledge.

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